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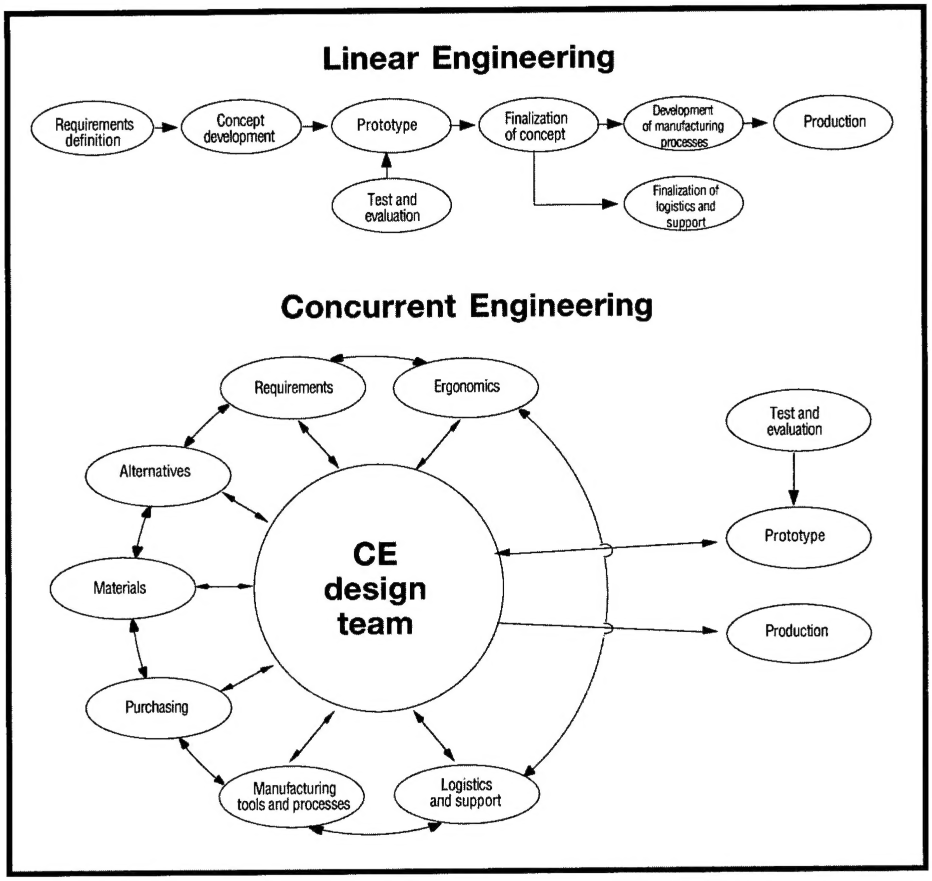

Figure 1. Product development under conventional linear engineering and under concurrent engineering.

In this issue:

CSERIAC is a United States Department of Defense information analysis center hosted by the Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, and operated by the University of Dayton Research Institute.

ERGONOMICS IN CONCURRENT ENGINEERING

Major M. Colleen Gorman

The Institute for Defense Analyses has defined concurrent engineering (CE) as "a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements" (Report R-338).

Concurrent engineering can lead to better products with lower life-cycle costs and shorter development times than under standard engineering approaches. These results are achieved through integrated product development—designers, manufacturers, suppliers, and customers all participate in the development process, and all participate throughout the process, thus

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Ergonomics, from page 1
the name "concurrent engineering."

While the name given to this concept may change from company to company and even within the Department of Defense (for example, the Air Force's Aeronautical Systems Division refers to this approach as "integrated process development" and the Air Force Human Resources Laboratory refers to it as "simultaneous engineering"), the themes generally remain the same.

Above all, concurrent engineering is a different way of looking at a product than the traditional "American way." Improvement of the product and the associated manufacturing and support processes is viewed as an ongoing effort that is the responsibility of everyone involved. Concurrent engineering focuses on meeting the customer's requirements and holds that quality must be built in, not added on or inspected in.

In traditional sequential (linear) engineering, information flows in only one direction, and each activity must be essentially complete before the next activity begins. In contrast, concurrent engineering has feed-forward and feedback information loops, allowing decisions to be based on information from all the affected areas (see Fig. 1).

In addition, the traditional design team is expanded to include representatives from marketing, manufacturing, key suppliers, and the customer, as well as other specialists. Team members work as equals in a climate of trust and ownership to enhance the design by helping identify and solve problems earlier in the design process.

The use of concurrent engineering delays the final configuration of the product until relatively late in the development process. However, it also reduces changes during manufacture and results in fewer modification requests from customers.

The delay in setting final design parameters also affects the distribution of life-cycle cost (LCC). In standard design practice, future LCC is fixed early on, because product design decisions are made early in the development process. In concurrent engineering, by contrast, the deferral of a final product design means that the bulk of LCC is not committed until full-scale production. Total LCC is also lower, despite higher initial cost in early design phases (see Fig. 2).

Many of the ideas and techniques of concurrent engineering are not new. However, their implementation has become much easier in recent years due to the vast improvement in relatively inexpensive computer power and the development of computer-based design tools (CAD/CAM/CAE).

Computationally intense activities such as finite-element modeling and calculation of aero- or fluid dynamics are no longer limiting factors in the analysis of various design options. State-of-the-art computer database management ensures that design changes are reflected in all drawings. Blueprints are no longer paper, but digital data, and can be represented more clearly in three-dimensional CAD displays, enhancing CE processes.

Concurrent engineering is also bolstered by increased use of analytical techniques (such as statistical process control methods and fault tree analysis) which help define optimum design and production parameters and support system tradeoff decisions.

The Role of Ergonomics

Concurrent engineering does not happen merely by management fiat. It requires changes in organizational structure, skillful technical management, and a long-term profit outlook. To succeed, these fundamental, far-reaching changes must be supported and led from the very top and must be supplemented by altered engineering practices.

Ergonomics can contribute to the CE process in two major ways. First, input from ergonomics is needed to help bring about the cultural changes in corporate and government management and decision making necessary to implement CE.

Second, as is becoming more widely recognized, optimal system efficiency and effectiveness require that ergonomics considerations be incorporated into every level of system design, including operation, maintenance, command and control functions, and diagnostic requirements. Since the human portion of the system is the single most expensive element in the life-cycle cost, good concurrent engineering of ergonomics-related aspects can have great impact on improving military system acquisition.

Ergonomic Management Initiatives

The cultural changes required to initiate a concurrent engineering approach within an organization affect everyone in the organization. Top-level managers must lead and actively support the change, not merely agree to it. In addition, difficult transitions are required at the middle management level. Under concurrent engineering, mid-level managers are no longer just functional, chain-of-command decision makers. Instead, they become primarily CE team coaches and resource managers. They are expected to motivate and support team members in their functional areas, but they lose some of their previous authority, as decisions are made by the team.

The primary need for ergonomics support is at the CE team level. The increasing complexity of DOD design has led to increasing specialization and compartmentalization. This so-called stovepipe mentality drives experts to try to optimize their own portions of the design, even at the expense of other areas. These experts must now become part of the CE team and must learn how to be team members.

A recent AF Aeronautical Systems Division white paper identified the following as areas in which training will be necessary: quality culture, teamwork, team member participation, team norms, stages in team development, team leadership, consensus decision making, constructive conflict in discussions, management of difficult people,

communications, problem solving, and confidentiality.

While entire papers could be written about the issues involved in each of these areas, some examples from two—communications and consensus decision making—will illustrate the types of questions ergonomics can help answer.

Despite the tremendous benefit of CAD/CAE to the design community, CAD/CAE workstations remain single-user units. Will this need to be changed to implement a CE program? If not, how will the design team communicate—through face-to-face meetings, electronic mail, teleconferencing? How often and for what part of the group will such communication be needed?

Studies suggest that communication is enhanced when a team is physically co-located. But, is this required for the entire team for the entire design process? What kind of space is best for team meetings? What is the role of computers in improving the team process? How, how much, and how often should the technical team communicate with the business and management teams? At what points in the process should design information be shared with the rest of the group, and who should be able to alter it?

This last question is closely related to consensus decision making. The CE team will work best if all members feel a sense of ownership in the product and processes. How can such a feeling be developed and maintained when not everyone's desires can be incorporated? On the other hand, once feelings of ownership are established, the team may defend a chosen alternative unreasonably.

In typical design practice, the desire is for rapid selection of a design concept; in concurrent engineering, however, the decision should be delayed to allow for a complete evaluation of alternatives and their implications. How to best accomplish this may require more research on the psychological and sociological aspect of design teams.

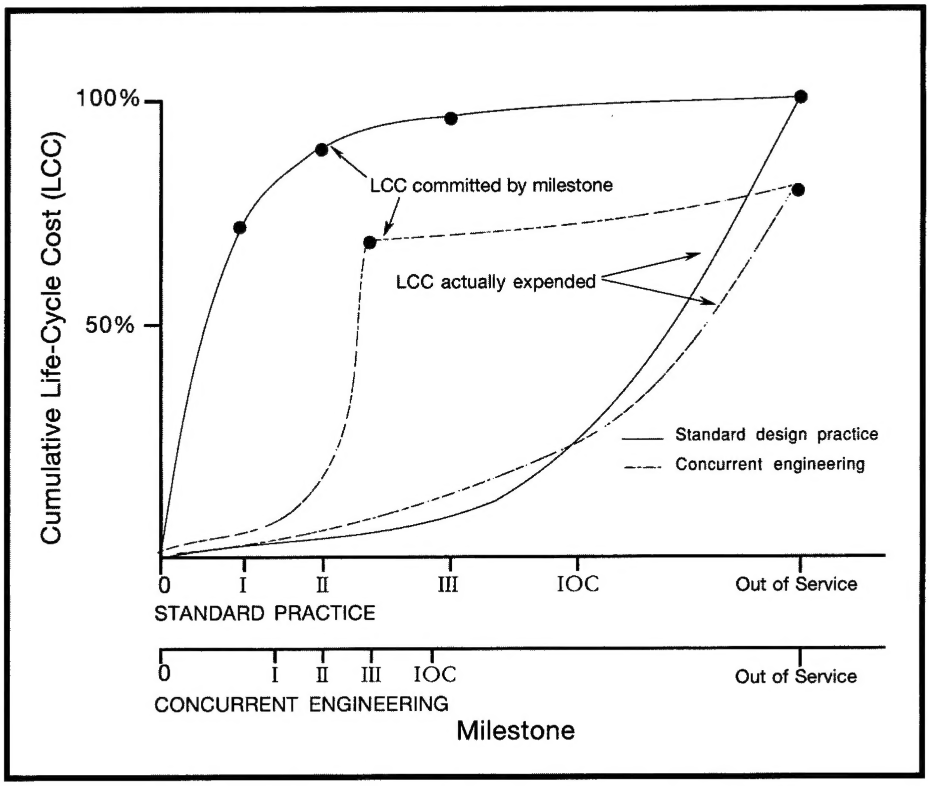

Figure 2. Typical life-cycle cost (LCC) and payout schedule under standard linear design compared with theoretical cost and payout under concurrent engineering. Milestones indicate the beginning of concept exploration (0), demonstration and validation (I), full-scale development (II), production (III), and initial operational capability (IOC). Note the shorter overall design time and longer service life with concurrent engineering.

Ergonomics in the Design Process

In the past, ergonomics has generally been given little more than lip service in the overall design process. When ergonomics *is* formally considered, it has usually been lumped in with the "-ilities," primarily maintainability and supportability.

In traditional linear design practice, these aspects are generally not determined until relatively late in the process, when most of the design is already fixed. In concurrent engineering, ergonomics practitioners are part of the design team from the beginning. They will thus have a much better chance to influence design so that human abilities and limitations are properly taken into account.

For this to occur, designers and users must be convinced that ergonomically motivated improvements and system-level tradeoffs yield a payback in life-cycle cost (LCC). In a weapons system, the cost of manpower is generally considered to be around 35 percent of the LCC. According to studies by Westinghouse, over 90 percent of the LCC is fixed prior to full-scale production. Thus, early ergonomics input to improve the human-centered aspects of design can potentially have a significant impact on LCC (see Fig. 2).

For ergonomics information to be effectively integrated into the design process, however, it must be made available in a form that can be used to support tradeoff decisions and help solve design problems, not merely provide a passive description of what is wrong.

In today's and tomorrow's design environment, it is also important that ergonomics information be compat-

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TECHNOLOGY TRANSFER

NASA Workload Assessment Software

CSERIAC can now provide its users with three microcomputer-based workload assessment tools developed by the Aerospace Human Factors Research Division at NASA-Ames Research Center (Moffett Field, CA).

NASA Task Load Index

The NASA Task Load Index (NASA-TLX) is a widely used multidimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: (1) Mental Demands, (2) Physical Demands, (3) Temporal Demands, (4) Own Performance, (5) Effort, and (6) Frustration.

The NASA Task Load Index uses a two-part procedure in which a subject first performs pairwise comparisons of the relative contribution of each subscale to overall workload and then provides numerical ratings on each subscale estimating that scale's contribution to total workload. A single overall workload score is then obtained by averaging the ratings, which are weighted according to their perceived relative contribution.

The NASA-TLX is implemented in both computerized and paper-and-pencil versions. The computerized version runs on IBM/PC-compatible computers with color graphics capability. The program is provided on a 360K diskette containing both source (Turbo Pascal) and executable code. Hard-copy documentation is included. NASA-TLX is available from CSERIAC for a cost-recovery fee.

Workload Consultant for Field Evaluation

The Workload Consultant for FIELD Evaluation (WC FIELDE) is a decision support system that helps users select workload assessment measures appropriate to a given application from a large pool of currently available techniques. The program asks the user a series of multiple-alternative questions about the specific environment, workload assessment goals, the nature of the tasks to be evaluated, and practical constraints. The answers to these questions are matched against the program's knowledge base, expressed in the form of IF-THEN-ELSE rules, and particular workload assessment measures are suggested.

WC FIELDE considers most of the major performance, physiological, and subjective measures in its decision-making process. It also provides specific information about each of the measures on request.

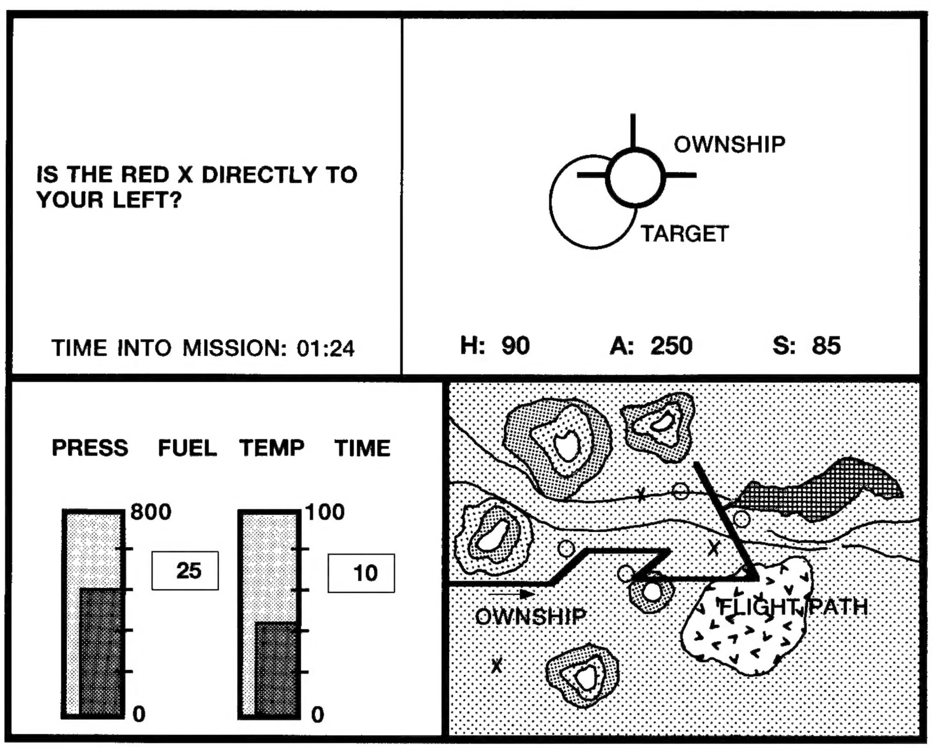
WC FIELDE was created using EXSYS, a commercially available expert system shell written in C. WC FIELDE runs on IBM/PC-compatible computers with 320K RAM. It is available on three 360K or one 1.4MB diskette with hard-copy documentation. The program can be obtained from CSERIAC for a cost-recovery fee.

Workload/Performance Simulation

The Workload/PerformANcE Simulation (Window/PANES) is a simple simulation of a flying task designed as a tool for researching the effects of complex task structure and subtask demands on workload, training, and performance.

The subject is presented with a four-panel window used to display (1) alphanumeric messages; (2) head-up graphics depicting commanded and current speed, heading, and altitude; (3) various analog or digital instrument gauges; and (4) a "God's eye" map showing geographic features, flight path, ownship position and heading,

NASA, on page 11



Representation of a sample Window/PANES display.

CHIEF SCIENTIST'S REPORT

Donald J. Polzella

Last issue, in this column, I described in some detail several case studies illustrating how CSERIAC goes about responding to user requests for technical or bibliographic information. Apparently, this was a worthwhile exercise. Many of our readers found the descriptions both useful and entertaining and asked that we continue to include them in the **Gateway**. I am happy to oblige, since I believe the case studies comprise an important source of "lessons learned" for the crew system designer community.

Night Vision

Our technical staff typically spends 5-8 hours responding to a technical or bibliographic inquiry but, occasionally, a request may require a more extensive effort—in the following case, over 100 hours! A senior-level government visual scientist was about to undertake a testing program to evaluate the performance characteristics of newly acquired "low profile" night-vision goggles and requested that we conduct a bibliographic search in the areas of night-vision goggles and image intensifier tubes. Of primary interest were quantitative studies that related the measurable characteristics of the goggles to human performance, but he was also interested in obtaining information describing the measurement procedures used to characterize the devices.

The search yielded several hundred citations from the technical report and journal literature. We obtained copies of approximately 20 seminal reports and articles and wrote a technology assessment, in which we summarized test procedures and data on field of view, acuity measures, luminance gain, center of gravity, interpupillary adjustment distance, modulation transfer function, and signal-to-noise ratio.

True Colors

A research psychologist at the Naval Ocean Systems Center was interested in information on the use of color to code quantitative information such as temperature or probability. A search of the DTIC and NASA bibliographic databases turned up over 100 citations. We provided the researcher with a summary of this literature, which suggested that color is a useful means of assisting operators in searching for and identifying classes of information that remain stable over time. While these studies most often involved categorization of qualitative data, color was used to portray ranges, conditions, or states of quantitative data as well. Apparently, the primary advantage of using color to code either type of data lies in its value for organizing or "chunking" information.

It may not be prudent to use color coding in an arbitrary or unsystematic manner, however. We noted that the Society of Automotive Engineers Aerospace Recommended Practice, "Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays" (ARP4032, April 1988) states that "color should not be used to code quantitative information unless that information can be divided into a small number [i.e., 5-9] of distinct categories such as has been done for color coded weather radar maps."

School Days

Imagine that in three weeks you had to teach a graduate-level course in human engineering, but you had no formal training in the area. How would you begin? This was the challenge faced by an Army major, trained as a systems engineer, who was invited to teach the course "Human Factors in Operations Research" at the Air Force Institute of Technology.

Like many who are outside our field, his view of human factors was limited to the motivational aspects of human performance. We gave him a two-hour crash course, in which we emphasized the role of human factors engineering in crew system design.

His most immediate need was to decide on a text for the course. *Books in Print* provided a useful, though daunting, list of 125 candidates under the category "Human Engineering." We assembled a manageable subset for the major and presented a "show and tell" on their contents. He decided on two texts: McCormick and Sanders' *Human Factors in Engineering Design* and Bailey's *Human Performance Engineering: A Guide for System Designers.*

Glaring Errors

Radar surveillance operators were reporting difficulties in reading a display that was a component of the Navy's Aegis control system. The display, a P39 phosphor CRT, was located on the ship bridge, where levels of ambient illumination could be quite high. A consulting engineer with a major aerospace systems designer and manufacturer hoped to improve the display's legibility and needed to determine the range of ambient illumination levels encountered on ship bridges.

We spoke with lighting experts in industry and the Navy, but no one could immediately provide the data the engineer needed. One of these contacts proved fortuitous, however. An officer and physician at the U.S. Naval Health Center had previously investigated legibility of light-emitting displays in low levels of ambient illumination and offered to collect high-level illumination data for the engineer. He had all the necessary equipment—including the ship bridge! ●

THE COTR SPEAKS

Major (Lt. Col. Select) Philip Irish, III

As the newly appointed Contracting Officer's Technical Representative (COTR), I am enjoying my first opportunity to write for the **Gateway**. Consequently, my comments will be limited to some initial observations about information analysis centers (IACs) generally and the CSERIAC program specifically.

First, there is no doubt that, as the total defense budget deflates, there will be a corresponding reduction in defense R&D expenditures. As *Science* magazine has pointed out, even during the Reagan years of unprecedented buildup, the defense basic and exploratory R&D budget did not keep pace with inflation, let alone grow, in proportion to the growth of other accounts.

Spending priorities in the past have not favored basic research and development, and the situation is not likely to improve in a more austere future. It appears, then, that efforts to develop "new" knowledge will increasingly wane as R&D monies dry up. As a result, there will be a greater and greater need to fully exploit the lessons of "old" knowledge, i.e., information already developed. The DoD IACs, including CSERIAC, provide a mechanism for just such an examination and exploitation of existing technical knowledge. Their role in developing the technology base should become more and more important. IACs should prosper even in the coming decade of drawdown.

Regarding CSERIAC, it is obvious the program has quickly attained full operational capability. After less than two years on the growth curve, CSERIAC is prepared to provide customers with the full range of IAC services intended at its outset: quick responses to technical inquiries, publication of state-of-the-art reports (SOARs), hosting of technical conferences and symposia, access to computerized ergonomics tools and databases, and so on. My hat's off to the CSERIAC team and especially to the previous COTR, Lt. Col. John Edwards, for having shared in the establishment of a first-class IAC.

CSERIAC has begun to successfully "market" a number of crew system ergonomics tools, models, and databases to governmental agencies, private industry, and academic institutions. Most of our current items have come from USAF sources because of their proximity and ease of access. However, we are in search of other government-owned or government-licensed ergonomics tools we can publicize to our customers or actually provide to them.

If any of our readership knows of ergonomics handbooks, processes, models, strategies, or databases that are of potential broad applicability in the human engineering community and that might be used by the government or its contractors with minimal cost or training, please give us a call or drop us a line about them. This will help us in our efforts to become a "one-stop shopping place" for state-of-the-art ergonomics information.

CSERIAC is also contemplating establishment of an on-line ergonomics bulletin board service. The purpose of such a bulletin board would be to facilitate the networking of human factors experts and the real-time sharing of ergonomics information worldwide. If anyone has thoughts about whether such a service would be useful and what capabilities should be included, again, please give us a call to share your ideas.

In summary, while the times ahead will be very volatile, CSERIAC is well positioned to provide increasingly important and expanded services to an international ergonomics community. ●

HARDMAN: Optimizing MPT Requirements

Commander George Council

The United States Navy's Hardware/Manpower Integration (HARDMAN) program was implemented in 1985 to facilitate early identification and supportability assessment of manpower, personnel, and training (MPT) requirements for all Navy acquisitions. Recognizing that approximately 50 percent of the total life-cycle cost of most weapon systems is devoted to manpower and training requirements, the Navy wanted the capability to accurately identify MPT requirements in early phases of weapon system design, when acquisition and design decisions can be influenced to reduce MPT expenditures without major increases in acquisition costs.

The HARDMAN program provides the tools and methodology necessary to project the MPT resource requirements of a weapon system prior to development of an actual prototype. These MPT data enable the program management office to perform tradeoff analysis and make meaningful program recommendations based on MPT considerations before the Navy becomes deeply committed to a specific design. The Navy can then avoid buying weapon systems it cannot staff and operate effectively.

Early MPT analysis also ensures that all advance planning and programming are completed well before the scheduled deployment of the weapon system. Chief among these predeployment requirements is the need to ensure that trained personnel will be available when the weapon system reaches the fleet.

The HARDMAN approach to MPT front-end analysis can be broken into three distinct phases. First, MPT goals and constraints for the new weapon system are identified early and are included in the formal program initiation documents. Next, after the weapon system definition and design begin, the HARDMAN methodology is used to project MPT resource requirements. Third, analysts in the offices of the Deputy Chief of Naval Operations for MPT (OP-01) and the Chief of Naval Education and Training (CNET) review and validate MPT requirements and conduct supportability assessment to determine if projected personnel inventories will be available to support introduction of the system and if training can be funded.

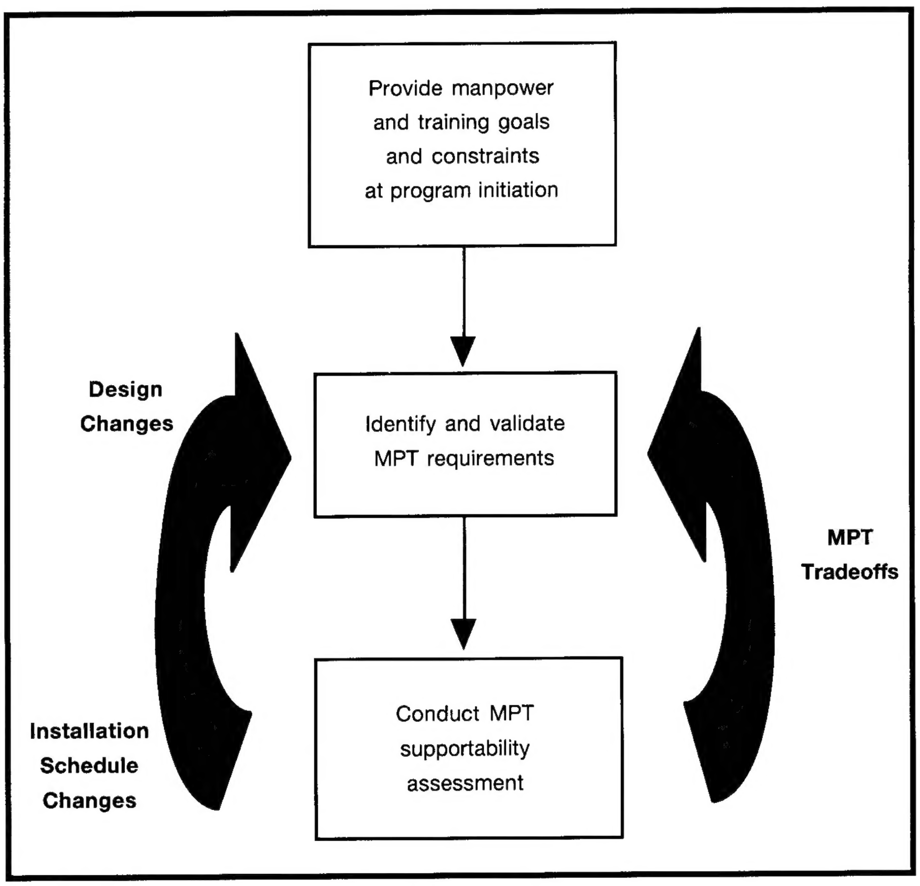
Steps two and three are iterative, and MPT requirements and supportability assessments are continually updated as weapon system design and development progress.

Unlike other MPT front-end analysis tools intended to "influence design," the HARDMAN methodology was developed primarily as an MPT requirements determination tool. Designs can be influenced by providing specific MPT constraints and goals at program initiation.

The HARDMAN methodology provides the analytical tools needed to develop and validate early projections of weapon system MPT requirements. It comprises a set of documented procedures to be followed in estimating MPT requirements and provides a standard format for recording data to ensure consistency and auditability.

The HARDMAN methodology has recently been updated and automated

HARDMAN, on page 8



The HARDMAN process.

HARDMAN, from page 7

for use in a PC environment. The entire methodology is contained on five diskettes and is readily available to all program managers within the Navy system commands. Users of the methodology need only a basic understanding of Navy manpower and training terminology and planning procedures, and can easily sequence through the entire process using detailed user's manuals. Three-day training workshops are conducted quarterly for hands-on users of the methodology.

HARDMAN tools for supportability analysis allow Navy decision makers to assess manpower requirements and resources on a Navy-wide basis and use aggregated manpower data to evaluate development options. This helps the Navy make maximum use of its available manpower resources by tailoring its weapon system inventory to its manpower resource base.

Currently, the HARDMAN methodologies and governing directives are being expanded and updated to provide greater emphasis on MPT even in smaller programs (Acquisition Categories III and IV) as well as for nondevelopmental items (off-the-shelf purchases) and rapid prototyping.

Implementation of Department of Defense Directive 5000.53 (Manpower, Personnel, Training and Safety in the Defense System Acquisition Process) within the Department of the Navy will require earlier and wider application of HARDMAN to satisfy the need for early MPT planning.

Information on the HARDMAN program, program documentation, and training workshops can be obtained from the Chief of Naval Operations (OP-123F), Washington, DC, 20380-2000. Point of contact is Commander George Council, (202) 693-1943, autovon 223-1943. ●

Commander Council heads the Navy's Future Manpower Requirements Section in the offices of the Deputy Chief of Naval Operations for Manpower, Personnel, and Training (OP-01) and is the HARDMAN Program Manager.

Strength Aptitude Test

The strength capabilities required to perform various operational and maintenance tasks can be of major concern in ensuring optimal functioning of systems and equipment.

For example, CSERIAC analysts recently fielded a technical inquiry from an engineer designing a hand-held sighting device whose projected weight was considerably more than the prescribed limit for other hand-held optical instruments. The engineer needed to know whether the strength required to hold the device with reasonable steadiness using both hands exceeded what could legitimately be expected of the personnel who would be operating the equipment.

Similar questions regarding the strength requirements of various Air Force assignments prompted the initiation of the Strength Aptitude Test (SAT) Program, a project to measure the strength capabilities of recruits and analyze the physical demands of Air Force jobs. CSERIAC is participating in this important Air Force effort.

The Air Force registers approximately 230 major categories of enlisted jobs, termed Air Force Specialty Codes (AFSC). The majority of these jobs have no significant physical work associated with them. The rest incorporate varying degrees of physically demanding work ranging from moderate to very heavy.

To ensure that those jobs with a significant physical component are performed efficiently, criteria must be developed for selecting individual workers to fill these specialties. The purpose of the SAT program is to establish relevant and objective criteria for assigning Air Force personnel to physically demanding jobs. In addition to ensuring that job performance requirements are met, an efficient system for matching physical capabilities of workers to jobs reduces job-related injuries caused by overexertion. Finally, although women, as a group, have less muscular strength than men, arbitrary physical strength criteria are discriminatory. The only legitimate procedure for establishing assignment criteria is to relate them to the real requirements of the job. One goal of the SAT program is to develop a gender-free test procedure.

The Air Force has had a strength test, the Factor-X Test, in use since March 1976. The original Factor-X Test required recruits to lift 20-, 40-, and 70-pound weights to demonstrate ability to perform light, medium, and heavy work. These weight limits were also used to categorize specialty codes into one of these three groups, based on weight-lifting requirements. From its inception, however, the Factor-X Test was considered an interim procedure, and work was begun immediately to develop improved physical strength and endurance assignment criteria.

In 1977, the Air Force Aerospace Medical Research Laboratory (AFAMRL, now the Harry G. Armstrong Aerospace Medical Research Laboratory) was asked by the Air Force Surgeon General to develop physical strength assignment criteria to replace the Factor-X test procedure. AFAMRL began by conducting an integration study on contract with Texas Tech University in 1977.

The new test series is known as the Strength Aptitude Test (SAT). Because of the failure of the original Factor-X Test to adequately screen workers entering specialties involving manipulation of the very heaviest weights, data from the SAT development program were used to revise the test. A new 100-pound weight was added to the test series and the 20-pound weight was eliminated. The SAT weight-lifting test is performed by all recruits as a basis for job assignment.

The current strength requirements for Air Force enlisted jobs were adopted after extensive analysis of the task components of each AFSC and the

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Ergonomics, from page 3
ible with and interface to CAD/CAE systems.

Several tools are in place to aid in the analysis of human-centered design. DODD 5000.53 directed that tools be developed to integrate manpower, personnel, training, and safety (MPTS) concerns in cost and tradeoff of design. Although the Air Force Logistics Composite Model (LCOM), a simulation used to predict manpower requirement for maintenance, has been available for many years, it is not sufficient. The Army Manpower and Personnel Integration (MANPRINT) program is currently developing a suite of tools that will make possible better analysis and solutions of MPTS problems throughout the acquisition process.

Graphical anthropometric models provide designers and ergonomics analysts a view of the system from the operator/maintainer standpoint. Current models, such as the Air Force's COMBIMAN and CREW CHIEF, as well as the work being done by the Army and NASA with the JACK modeling environment (developed at the University of Pennsylvania) can provide useful, usable ergonomics information within the CAD world. The Air Force is also working on tools to improve the design of command and control console displays, action access (keyboard, mouse, touch screens, etc.), and information presentation aids.

Much work remains to be done. Rule-based design systems, in development for hardware and software, need to be created for the human side of the design as well. Improved MPT analysis needs to be linked to logistics, and the whole must yield results that can be evaluated systematically in tradeoffs across domains, not just within ergonomics. Changes in human system design have an impact on life-cycle cost and system performance. The challenge to the ergonomics community is to ensure that these impacts are quantifiable and visible.

Without appropriate inputs from ergonomics, concurrent engineering will be unable to fully realize all the cost, performance, and schedule benefits it offers.

Conclusions

Concurrent engineering has the potential to achieve profound improvements in cost, schedule, product performance, and customer satisfaction. Ergonomics plays an important role in ensuring that the changeover to a concurrent engineering approach takes account of accompanying changes in authority and responsibility, and that team members have the appropriate tools for integrated team decision making.

In addition, ergonomics must be considered throughout the system design process to ensure the optimal integration of human and machine, and the impacts of ergonomic-related decisions on life-cycle cost and system performance must be quantified so that system-level tradeoffs can be made and understood. ●

Major Colleen Gorman is the group leader for Human Centered Technology for Design in the Logistics and Human Factors Division of the Air Force Human Resources Laboratory, Wright-Patterson AFB, Ohio. Much of the CE information in this article is based on R.I. Winner, J.P. Pennell, H.E. Bertrand, and M.M. Slusarczuk, The Role of Concurrent Engineering in Weapons System Acquisition, *Institute for Defense Analyses, IDA Report R-338, December 1988.*

Oops!

The telephone number for INFO/tek, publisher of *Information Resources for Engineers and Scientists*, was reported incorrectly in the Recommended Reading section of the Spring issue. The correct number is: (202) 363-9147.

CALENDAR

July 22-27, 1990
22nd International Congress of Applied Psychology. Kyoto, Japan. Sponsored by the International Association of Applied Psychology. Contact Travel Planners, Suite 150, GPM Building, San Antonio, TX 78216; (512) 341-8131, fax (512) 341-5252.

August 12-16, 1990
2nd International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation. Honolulu, HI, Hilton Hawaiian Village. Sponsored by the University of Louisville and the International Ergonomics Association. Contact Mansour Rahimi, Institute of Safety and Systems Management, University of Southern California, Los Angeles, CA 90089-0021; (213) 743-8972, fax (213) 747-7182.

August 27-31, 1990
INTERACT '90, 3rd International Conference of Human-Computer Interaction. Cambridge, England, University of Cambridge. Sponsored by the British Computer Society. Contact Conference Office, British Computer Society, 13 Mansfield St., London W1M 0BP, England; 44-1-637-0471, fax 44-1-631-1049.

September 26-28, 1990
3rd International Conference, Human Machine Interaction and Artificial Intelligence in Aeronautics and Space. Toulouse- Blagnac, France. Contact G. Picchi, CERT, B.P. 4025, 31055 Toulouse Cedex, France; 61 55 70 01, fax 61 55 71 72.

October 8-12, 1990
34th Annual Meeting of the Human Factors Society. Orlando, FL, Stouffer Orlando Resort. Contact the HFS Central Office, P.O. Box 1369, Santa Monica, CA 90406; (213) 394-1811 or 394-9793, fax (213) 394-2410. Poster deadline July 13, 1990.

Notices for the calendar should be sent to CSERIAC Gateway Calendar, CSERIAC Program Office, AAMRL/HE/CSERIAC, Wright-Patterson AFB, OH 45433-6573, at least four months in advance.

New Product Notice: CSERIAC is anticipating the distribution of a new product that will be used for Small Unit Maintenance Manpower Analysis (SUMMA). More to come later or call CSERIAC for information.

NASA, from page 4
target position, and other information.

The subject's primary task (essentially pursuit tracking) is to regulate the speed, heading, and altitude of the controlled aircraft to maintain the same flight path as the target.

The speed, heading, and altitude of the target can be manipulated by the experimenter to create different scenarios. In addition, the subject may be required to acknowledge or evaluate information presented on the map, values shown on the gauges, or alphanumeric messages.

Window/PANES runs on an IBM/AT-compatible computer with at least 1MB of RAM, a 20MB hard disk, an 80287 math co-processor, and an 8- or 10-MHz CPU. The program is written to operate with a high-resolution (EGA) color monitor and a Cyborg ISAAC interface to read subject inputs from a user-customized response box. In addition, a mouse and the Dr. Halo III graphics program are needed to develop the map.

Window/PANES is provided on two 1.4MB diskettes (one contains a demonstration) with hard-copy documentation. The program is available from CSERIAC for a cost-recovery fee.

Distribution of all three NASA workload assessment tools is unclassified and unlimited. ●

SAT, from page 9
strength capabilities of personnel working in the specialty. A minimum strength criterion has been set that is a prerequisite for admission to each AFSC.

The makeup and duties of an AFSC do not always remain constant over time, however. AFSCs may be subdivided or combined to create new ones. In some cases, the systems and equipment used in an AFSC change, so that strength requirements become outdated.

Under the management of CSERIAC, strength aptitude categorizations for AFSCs are reviewed on a revolving basis. Periodically, AFSCs are reanalyzed, the physical demands associated with each specialty are determined, and strength requirements are updated if necessary. ●

Busy Signal?

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Summer 1990

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CSERIAC's objective is to acquire, analyze, and disseminate timely information on crew system ergonomics (CSE). The domain of CSE includes scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs, performance, body dimensions, biomechanical dynamics, strength, and tolerances. It also encompasses engineering and design data concerning equipment intended to be used, operated, or controlled by crew members.

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- reference resources such as handbooks and data books.

Within its established scope, CSERIAC also:

- organizes and conducts workshops, conferences, symposia, and short courses;
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